Units & Dimensions.
SI units & U.S. Customary units.

نسألكم الدعاء

يوجد للتصميم فى مصر نوعان من الوحدات :

١ـ النظام القديم *Metric System* و نستخدم فيه Ton , Kg , m & cm

٢ـ النظام الحديث (*S I*) و هو حاليا النظام العالمى (*System International*)

و يوجد نظام ثالث غير مستخدم فى مصر لكن يستخدم فى أوربا و أمريكا
يسمى (*British units* or *U.S. Customary units.*)

للتحويل من *Metric System* الى *S I* ←

Kg = 9.81 N ≃ 10.0 N
ton = 9.81 kN ≃ 10.0 kN

و الجدول التالى يوضح كيفيه التحويل من النظام *Metric System* الى *S I* مع أمثله لتوضيح ذلك

	Metric System	S I
Concentrated Load	*Kilogram* (Kg)	*Newton* (N)
	1 Kg ≃ 10 N	
	Ton (t)	*kilo Newton* (kN)
	1 ton ≃ 10 kN	
Length	*meter* (m)	*meter* (m)
	centimeter (cm)	*millimeter* (mm)
	1 cm = 10 mm	
Distributed Load (w)	w t/m\` ; L ; $w$ (t/m\`)	w kN/m\` ; L ; $w$ (kN/m\`)
	1 t/m\` = 10 kN/m\`	

	Metric System	SI
Bending Moment (M)	M M (t.m) عند حساب الاحمال M (Kg.cm) فى معادلات التصميم لتحويل قيمه العزم من (t.m) الى (Kg.cm) يتم ضرب قيمه العزم فى 10^5	M M (kN.m) عند حساب الاحمال M (N.mm) فى معادلات التصميم لتحويل قيمه العزم من (kN.m) الى (N.mm) يتم ضرب قيمه العزم فى 10^6
	1 t.m. = 10 kN.m	
	1 Kg.cm = 100 N.mm	
Dimensions of sections.	t, d, b b, d & t (m) عند حساب الاحمال b, d & t (cm)	t, d, b b, d & t (m) عند حساب الاحمال b, d & t (mm) فى معادلات التصميم
Area of Steel Bars (A_s)	cm^2	mm^2
	1.0 cm^2 = 100 mm^2 EX. 1 Ø16 ≃ 2.01 cm^2 ≃ 201 mm^2	
Distributed	t\m ^{2}	kN\m ^{2}
Load at m^2	1 t\m ^{2} ≃ 10.0 kN\m ^{2} EX. L.L. = 0.20 t\m ^{2} ≃ 2.0 kN\m ^{2} EX. F.C. = 0.15 t\m ^{2} ≃ 1.50 kN\m ^{2}	

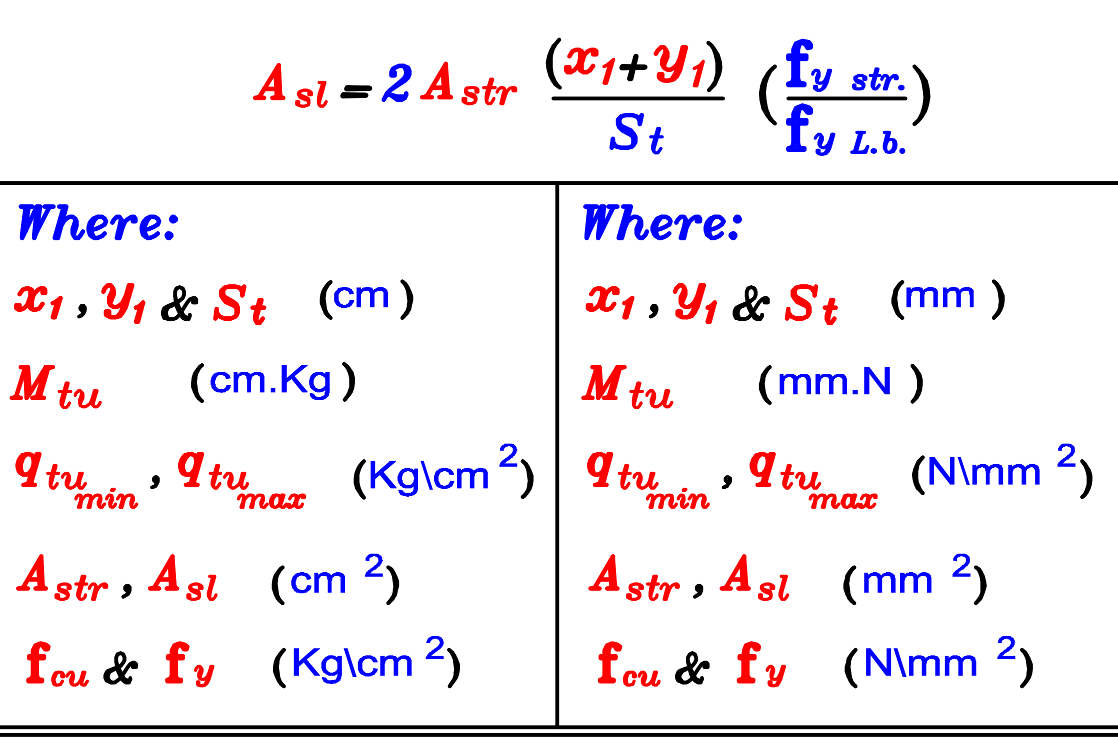
	Metric System	SI
Stress	kg\cm ^{2}	N\mm ^{2} = MPa = **Mega Pascal**
	1 kg\cm ^{2} ≃ 0.10 N\mm ^{2} EX. $f_{cu} = 250$ kg\cm ^{2} ≃ 25 N\mm ^{2} EX. $f_y = 3600$ kg\cm ^{2} ≃ 360 N\mm ^{2}	
density	t\m ^{3}	kN\m ^{3}
	t\m ^{3} ≃ 10.0 kN\m ^{3} EX. $\gamma_c = 2.50$ t\m ^{3} ≃ 25.0 kN\m ^{3} EX. $\gamma_{wall} = 1.80$ t\m ^{3} ≃ 18.0 kN\m ^{3}	
modules of Elasticity (E)	**For Concrete** $E_c = 14000\sqrt{f_{cu}}$ (kg\cm ^{2}) **For Steel** $E_s = 2 \times 10^6$ (kg\cm ^{2})	**For Concrete** $E_c = 4400\sqrt{f_{cu}}$ (N\mm ^{2}) **For Steel** $E_s = 2 \times 10^5$ (N\mm ^{2})
المقاومة المميزه للخرسانه chrasaristics strength (f_{cu})	f_{cu} (kg\cm ^{2}) 200 | 250 | 300 | 350 | 400 | 450	f_{cu} (N\mm ^{2}) = (MPa) 20 | 25 | 30 | 35 | 40 | 45
اجهاد الخضوع أو اجهاد الضمان للحديد yield stress or proof stress (f_y)	f_y (kg\cm ^{2}) st. 24\35 $f_y = 2400$ (kg\cm ^{2}) st. 36\52 $f_y = 3600$ (kg\cm ^{2}) st. 40\60 $f_y = 4000$ (kg\cm ^{2})	f_y (N\mm ^{2}) = (MPa) st. 240\350 $f_y = 240$ (N\mm ^{2}) st. 360\520 $f_y = 360$ (N\mm ^{2}) st. 400\600 $f_y = 400$ (N\mm ^{2})

ملحوظة : تصميم القطاعات فى هذه الملفات بطريقة حالات الحدود L.S.D.M.
Limits States Design Method

<table>
<tr><th></th><th>Metric System</th><th>S I</th></tr>
<tr><td rowspan="2">Design of section subjected to Bending Moment using First Principles</td><td colspan="2">$$0.67\frac{f_{cu}}{\gamma_c}\,a\,b = A_s\frac{f_y}{\gamma_s}$$ $$M_{U.L.} = 0.67\frac{f_{cu}}{\gamma_c}\,a\,b\,(d-\frac{a}{2})$$ $$M_{U.L.} = A_s\frac{f_y}{\gamma_s}(d-\frac{a}{2})$$</td></tr>
<tr><td>Where:
a , b & d (cm)
A_s & A_c (cm ^{2})
f_{cu} & f_y (Kg\cm ^{2})
$M_{U.L.}$(cm.Kg) = $M_{U.L.}$(m.t) $\times 10^5$
$A_{s\,min.} = \frac{1.1}{f_y}A_c$</td><td>Where:
a , b & d (mm)
A_s & A_c (mm ^{2})
f_{cu} & f_y (N\mm ^{2})
$M_{U.L.}$ (mm.N) = $M_{U.L.}$(m.kN) $\times 10^6$
$A_{s\,min.} = \frac{11}{f_y}A_c$</td></tr>
<tr><td rowspan="2">Design of section subjected to Bending Moment using Charts
C_1 & J Chatr</td><td colspan="2">$$d = C_1\sqrt{\frac{M_{U.L.}}{f_{cu}\,b}}$$ $$A_s = \frac{M_{U.L.}}{J\,f_y\,d}$$</td></tr>
<tr><td>Where:
b & d (cm)
A_s & A_c (cm ^{2})
f_{cu} & f_y (Kg\cm ^{2})
$M_{U.L.}$ (cm.Kg) = $M_{U.L.}$(m.t) $\times 10^5$
$A_{s\,min.} = \frac{1.1}{f_y}A_c$</td><td>Where:
b & d (mm)
A_s & A_c (mm ^{2})
f_{cu} & f_y (N\mm ^{2})
$M_{U.L.}$(mm.N) = $M_{U.L.}$(m.kN) $\times 10^6$
$A_{s\,min.} = \frac{11}{f_y}A_c$</td></tr>
</table>

	Metric System	SI
Design of section subjected to Compression Force only	$P_{U.L.} = 0.35\, A_c\, f_{cu} + 0.67\, A_s\, f_y$	
	Where: $P_{U.L.}$ (Kg) A_c & A_s (cm^2) f_{cu} & f_y ($Kg\backslash cm^2$)	Where: $P_{U.L.}$ (N) A_c & A_s (mm^2) f_{cu} & f_y ($N\backslash mm^2$)
Design of section subjected to Tension Force only	$A_s = \dfrac{T_{U.L.}}{f_y/\gamma_s}$ $A_c \simeq (20 \longrightarrow 40)\, A_s$	
	Where: $T_{U.L.}$ (Kg) A_c & A_s (cm^2) f_y ($Kg\backslash cm^2$)	Where: $T_{U.L.}$ (N) A_c & A_s (mm^2) f_y ($N\backslash mm^2$)
Design of section subjected to Compression Force & Bending Monent $M_{U.L.}$ & $P_{U.L.}$ Tension Failure	$e = \dfrac{M_{U.L.}}{P_{U.L.}}$ $e_s = e + \dfrac{t}{2} - c$ $M_{su} = P_{U.L.} \times e_s$ $A_s = \dfrac{M_{su}}{J\, f_y\, d} - \dfrac{P_{U.L.}}{f_y/\gamma_s}$	
	Where: e, e_s, c, d & t (cm) $P_{U.L.}$ (Kg) $M_{su}(cm.Kg) = M_{su}(m.t) \times 10^5$ f_y ($Kg\backslash cm^2$) A_s (cm^2)	Where: e, e_s, c, d & t (mm) $P_{U.L.}$ (N) $M_{su}(mm.N) = M_{su}(m.kN) \times 10^6$ f_y ($N\backslash mm^2$) A_s (mm^2)

	Metric System	SI
Design of section subjected to Compression Force & Bending Moment $M_{U.L.}$ & $P_{U.L.}$	$\frac{P_{U.L.}}{f_{cu}\,b\,t}$, $\frac{M_{U.L.}}{f_{cu}\,b\,t^2}$ $\mu = \rho \times f_{cu} \times 10^{-5}$ $A_s = \mu\, d\, t$ $A_s` = \alpha\, A_s$	$\frac{P_{U.L.}}{f_{cu}\,b\,t}$, $\frac{M_{U.L.}}{f_{cu}\,b\,t^2}$ $\mu = \rho \times f_{cu} \times 10^{-4}$ $A_s = \mu\, d\, t$ $A_s` = \alpha\, A_s$
Compression Failure using Interaction Diagram	**Where:** b & t (cm) $P_{U.L.}$ (Kg) $M_{U.L.}$(cm.Kg) = $M_{U.L.}$(m.t) $\times 10^5$ A_s (cm ^{2}) f_{cu} & f_y (Kg\cm ^{2})	**Where:** b & t (mm) $P_{U.L.}$ (N) $M_{U.L.}$(mm.N) = $M_{U.L.}$(kN.m) $\times 10^6$ A_s (mm ^{2}) f_{cu} & f_y (N\mm ^{2})
Check Shear	$q_u = \frac{Q_{U.L.}}{b\,d}$ $q_{cu} = 0.75\sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{u\,max} = 2.20\sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(f_y/\gamma_s)}{b\,S}$ $= \frac{n\,A_s}{b\,S} \geqslant \frac{0.4}{f_y}$ $\frac{A_{sb}}{b\,S} = \frac{q_{sub}}{(f_y/\gamma_s)(Sin\,\alpha + Cos\,\alpha)}$	$q_u = \frac{Q_{U.L.}}{b\,d}$ $q_{cu} = 0.24\sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_{u\,max} = 0.70\sqrt{\frac{f_{cu}}{\gamma_c}}$ $q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(f_y/\gamma_s)}{b\,S}$ $= \frac{n\,A_s}{b\,S} \geqslant \frac{4.0}{f_y}$ $\frac{A_{sb}}{b\,S} = \frac{q_{sub}}{(f_y/\gamma_s)(Sin\,\alpha + Cos\,\alpha)}$
	Where: b & d (cm) $Q_{U.L.}$ (Kg) q_u, q_{cu}, $q_{u\,max}$ (Kg\cm ^{2}) A_s (cm ^{2}) f_{cu} & f_y (Kg\cm ^{2})	**Where:** b & d (mm) $Q_{U.L.}$ (N) q_u, q_{cu}, $q_{u\,max}$ (N/mm ^{2}) A_s (mm ^{2}) f_{cu} & f_y (N\mm ^{2})

	Metric System	SI
Check **Shear** + **Torsion**	$q_{tu} = \dfrac{M_{tu}}{2\,A_o\,t_e}$ $q_{tu} = \dfrac{M_{tu}\,(x_1 + y_1)}{0.85\,(x_1^2 + y_1^2)}$ For R-sec.	
	$q_{tu_{min}} = 0.19\sqrt{\dfrac{f_{cu}}{\gamma_c}}$ $q_{tu_{max}} = 2.20\sqrt{\dfrac{f_{cu}}{\gamma_c}}$	$q_{tu_{min}} = 0.06\sqrt{\dfrac{f_{cu}}{\gamma_c}}$ $q_{tu_{max}} = 0.70\sqrt{\dfrac{f_{cu}}{\gamma_c}}$
	 $A_{str} = \dfrac{M_{tu}\,S_t}{1.7\,x_1\,y_1\,(f_y/\gamma_s)}$ $A_{sl} = 2\,A_{str}\,\dfrac{(x_1 + y_1)}{S_t}\,\left(\dfrac{f_{y\ str.}}{f_{y\ L.b.}}\right)$	
	Where: x_1 , y_1 & S_t (cm) M_{tu} (cm.Kg) $q_{tu_{min}}$, $q_{tu_{max}}$ (Kg\cm ^{2}) A_{str} , A_{sl} (cm ^{2}) f_{cu} & f_y (Kg\cm ^{2})	**Where:** x_1 , y_1 & S_t (mm) M_{tu} (mm.N) $q_{tu_{min}}$, $q_{tu_{max}}$ (N\mm ^{2}) A_{str} , A_{sl} (mm ^{2}) f_{cu} & f_y (N\mm ^{2})

SI units → U.S. Customary units

يوجد حاليا فى معظم دول العالم نوعان من الوحدات :

١ـ النظام الحديث (S I) و هو حاليا النظام العالمى (System International)
و يستخدم °C & N , mm و هذا هو النظام المستخدم فى مصر حاليا .

٢ـ النظام الانجليزى و هو النظام الغالب ايضا فى امريكا .
و يسمى (British units or U.S. Customary units.)
و يستخدم °F & lb , in

للتحويل بين النظامين

1 N ≃ 0.225 lb	
1 m ≃ 39.37 in	

و الاسهل للتذكر

1 Kg ≃ 2.20 lb	
1 in ≃ 2.54 cm	

و الجدول التالى يوضح كيفيه التحويل من النظام SI الى U.S. Customary

	S I	U.S. Customary
Concentrated Load	Newton (N)	Pounds (lb)
	1 N ≃ 0.225 lb	
	kilo Newton (kN)	kilo Pound (Kip)
	1 kN ≃ 0.225 Kips	
Length	Meter (m)	Feet (ft)
	1 m ≃ 3.28 ft	
	centimeter (cm)	inch (in)
	1 cm ≃ 0.39 in	
	2.54 cm ≃ 1 in	
	Meter (m)	yard (yd)
	1 m ≃ 1.094 yd	

<table>
<tr><th></th><th>S I</th><th>U.S. Customary</th></tr>
<tr><td rowspan="3">Distributed Load (w)</td><td>w kN/m`
L</td><td>w Kip/Ft
L</td></tr>
<tr><td colspan="2">1 N/m` ≃ 0.068 lb/ft</td></tr>
<tr><td colspan="2">1 kN/m` ≃ 0.068 Kip/ft</td></tr>
<tr><td rowspan="3">Bending Moment (M)</td><td>M
M (kN.m) عند حساب الاحمال
M (N.mm) فى معادلات التصميم</td><td>M
M (Kip.ft) عند حساب الاحمال
M (lb.in) فى معادلات التصميم</td></tr>
<tr><td colspan="2">1 kN.m ≃ 0.737 Kip.ft</td></tr>
<tr><td colspan="2">1 N.m ≃ 8.85 lb.in</td></tr>
<tr><td rowspan="4">Dimensions of sections.</td><td>b, d & t (m) عند حساب الاحمال</td><td>b, d & t (ft) عند حساب الاحمال</td></tr>
<tr><td colspan="2">1 m ≃ 3.28 ft</td></tr>
<tr><td>b, d & t (mm) فى معادلات التصميم</td><td>b, d & t (in) فى معادلات التصميم</td></tr>
<tr><td colspan="2">1 mm ≃ 0.04 ft</td></tr>
<tr><td rowspan="4">Area of Steel Bars (A_s)</td><td>mm^2</td><td>in^2</td></tr>
<tr><td colspan="2">1 mm^2 ≃ 0.00155 in^2</td></tr>
<tr><td colspan="2">الطريقه المستخدمه لتصنيف اقطار حديد التسليح مختلفه تماما فى النظام الامريكى .
حيث الوحده تقاس ب ($\frac{1}{٨}$) بوصه</td></tr>
<tr><td>EX. 1⌀16 → Diameter = 16 mm
$A_s = \frac{\pi * 16^2}{4} = 201\ mm^2$</td><td>EX. ※5 → Diameter = $\frac{5}{8}$ in
$A_s = \frac{\pi * (\frac{5}{8})^2}{4} = 0.306\ in^2$</td></tr>
<tr><td rowspan="2">Area Distributed Load</td><td>$kN\backslash m^2$</td><td>lb/in^2</td></tr>
<tr><td colspan="2">1 $kN\backslash m^2$ ≃ 0.145 lb/in^2</td></tr>
</table>

	SI	U.S. Customary
Stress	$N\backslash mm^2$ = MPa = *Mega Pascal*	$Kips/in^2$ = Ksi lb/in^2 = Psi
	$1\ N\backslash mm^2 \simeq 0.145$ Ksi	
	$1\ N\backslash mm^2 \simeq 145$ Psi	
	EX. $f_{cu} = 25\ N\backslash mm^2 \simeq 3625$ Psi EX. $f_y = 360\ N\backslash mm^2 \simeq 52.2$ Ksi عند توصيف الحديد نوصفه بـ Ksi و عند توصيف الخرسانه نوصفها بـ Psi و فى جميع الاحوال يجب استخدام Psi فى معادلات التصميم	
Density	kN/m^3	lb/ft^3
	$1\ kN/m^3 \simeq 6.24\ lb/ft^3$	
	EX. $\gamma_c = 25.0\ kN/m^3 \simeq 156\ lb/ft^3$ EX. $\gamma_{wall} = 18.0\ kN/m^3 \simeq 112\ lb/ft^3$	
modules of Elasticity (E)	*For Concrete* $E_c = 4400\sqrt{f_{cu}}$ $(N\backslash mm^2)$ *For Steel* $E_s = 2 \times 10^5$ $(N\backslash mm^2)$	*For Concrete* $E_c = 33 * \gamma_c^{1.5} * \sqrt{f_{cu}}$ (Psi) *For Steel* $E_s = 290 \times 10^5$ (Psi)
المقاومه المميزه للخرسانه *chrasaristics strength* (f_{cu})	f_{cu} $(N\backslash mm^2)$ = (MPa) 20 | 25 | 30 | 35 | 40 | 45	f_{cu} (lb/in^2) = (Psi) 2900 | 3625 | 4350 | 5075 | 5800 | 6525
اجهاد الخضوع أو اجهاد الضمان للحديد *yield stress or proof stress* (f_y)	f_y $(N\backslash mm^2)$ = (MPa)	f_y $(N\backslash mm^2)$ = (MPa)
	st. 240\350 $f_y = 240\ (N\backslash mm^2) \simeq 34800$ (Psi) st. 360\520 $f_y = 360\ (N\backslash mm^2) \simeq 52200$ (Psi) st. 400\600 $f_y = 400\ (N\backslash mm^2) \simeq 58000$ (Psi)	

	SI		U.S. Customary	
Rebars	رقم السيخ هو قطر السيخ بال mm EX. 1φ16 → Diameter = 16 mm $A_s = \frac{\pi * 16^2}{4} = 201\ mm^2$		رقم السيخ هو قطر السيخ بال in لكن مقسوم على ٨ EX. #5 → Diameter = $\frac{5}{8}$ in $A_s = \frac{\pi * (\frac{5}{8})^2}{4} = 0.306\ in^2$	
	φ	A_s	#	A_s
	φ 6	28.2 mm^2	# 2	0.049 in^2
	φ 8	50.3 mm^2	# 3	0.110 in^2
	φ 10	78.5 mm^2	# 4	0.196 in^2
	φ 12	113 mm^2	# 5	0.306 in^2
	φ 16	201 mm^2	# 6	0.441 in^2
	φ 18	254 mm^2	# 7	0.601 in^2
	φ 20	314 mm^2	# 8	0.785 in^2
	φ 22	380 mm^2	# 9	0.994 in^2
	φ 25	490 mm^2	# 10	1.227 in^2
	φ 28	615 mm^2	# 11	1.485 in^2
	φ 32	804 mm^2	# 12	1.767 in^2